Journal of Applied and Natural Science 10 (1): 482 – 486 (2018)

Performance of pearl millet under agri-horti system as influenced by sowing methods and integrated nutrient management in Vindhyan region of Uttar Pradesh, India

S. K. Verma[1], Ugrasen Yadav[1], Sushil Kumar[1&2*] and Kairovin Lakra[3]

[1]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005 (Uttar Pradesh), INDIA
[2]ICAR-Central Arid Zone Research Institute, Regional Research Station, Kukma -370105 Bhuj (Gujarat), INDIA
[3]Chandra Sekhar Azad University of Agriculture and Technology, Kanpur- 208002 (Uttar Pradesh), INDIA
*Corresponding author. E-mail:sushilangrau@gmail.com

Received: November 11, 2017; Revised received: December 12, 2017; Accepted: February 25, 2018

Abstract: An experiment involving three sowing methods and four integrated nutrient management practices was undertaken at Rajeev Gandhi South Campus, Banaras Hindu University in factorial randomized complete block design with three replications. The aim of the study was to assess the effects of sowing methods and integrated nutrients management practices on performance of pearl millet under agri-horti system. The sowing methods and integrated nutrient management practices significantly (P=0.05) influenced performance of pearl millet. Adoption of ridge and furrow sowing method recorded higher growth [plant height (147.7 cm), dry weight (72.7 g), and number of tillers plant^{-1} (2.0)], yield attributes [effective tillers hill^{-1} (1.77), panicle length (17.9 cm), grains panicle^{-1} (1508.3), grains weight panicle^{-1} (13.9), and test weight (9.23 g)], yields [grain yield (1412 kg ha^{-1}), and stover yield (3972 kg ha^{-1})], and economics [net returns (Rs. 36371 ha^{-1}), and B:C ratio (1.79) than broadcasting and raised bed. Application of 50% recommended dose of fertilizer + 50% poultry manure resulted higher growth [plant height (151.9 cm), dry weight (79.7 g), and number of tillers plant^{-1} (2.22)], yield attributes[effective tillers hill^{-1}(2.0), panicle length (18.8 cm), grains panicle^{-1} (1615.6), grains weight panicle^{-1} (14.5), and test weight (9.76 g)], yields [grain yield (1552 kg ha^{-1}), and stover yield (4360 kg ha^{-1})] and economics [net returns (Rs. 38227 ha^{-1}), and B:C ratio (1.77) than remaining integrated nutrient management practices. The combination of ridge and furrow and 50% recommended dose of fertilizer + 50% poultry manure was adjudged to be better for pearl millet performance.

Keywords: Agri-horti system, Integrated nutrient management, Pearl millet, Rainfed, Sowing methods

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.)crop having multiple uses as food, feed, fodder and fuelis considered the sixth most important cereal crop after wheat, rice, maize, sorghum and barley (Singh *et al.,* 2003). The crop is grown on an area of 31 million hectare (M ha) in the world (ICRISAT, 2016), while in India, it is grown on an area of about 6.98M hawith 8.06 million tonnes (Mt) production and 1154 kg ha^{-1} productivity, respectively (GOI, 2016).Being highly drought resistant crop, itis widely cultivated in rainfed areas of the country either as sole or as intercrop in agroforesty systems. Despite, poor management and unfavourable growing conditions *viz.* limited soil moisture supply and poor fertility status in rainfed areas, pearl milletthrives well but finally results in producing low yield. Adoption of improved agronomic practices such as sowing methods and integrated nutrient management (INM) not only enhance growth, yield and economics of crop (Parihar *et al.,* 2010; Sharma et al., 2015; Kumar *et al*., 2016) but also help in conserving precious natural resources (Bana *et al.,* 2016), improving soil fertility, soil structure, water holding capacity and root proliferation (Bana, 2006), besides improving ecosystem health. Since, the information on sowing methods and INM in pearl millet under guava based agri-horti systemin rainfed Vindhyan region of Uttar Pradesh is meager, the present study attempted to assess the effects of sowing methods and INM on the growth, yield attributes, yield and economics of pearl millet grown as inter crop under eight year old guava based agri-horti system in rainfed Vindhyan region of Uttar Pradesh, India.

MATERIALS AND METHODS

A field experiment was undertakenat Rajeev Gandhi South Campus, Banaras Hindu University, located at Barkachchha in Mirzapur district of Uttar Pradesh, India (Latitude: 25°10'; Longitude: 82°37' and Altitude: 427 m above the mean sea level) during the *kha-*

*rif*season of 2013-14. The climate of the study area is basically semi-arid to sub-humid nature. It recorded 746.11 mm rainfall during the cropping period. The maximum and minimum mean temperature was measured as 35.44^{0}C and 25.67^{0}C, respectively. The soil was sandy clay loam in texture, acidic in nature (pH 5.9)and had low available N (176.4 kg ha^{-1}), medium available P (12.15 kg ha^{-1}) and available K (186.5 kg ha^{-1}). The bulk and particle densityfrom 0-30 cm soil depth was recorded 1.53 and 2.48 Mg m^{-3}, respectively (Yadav, 2014). The experiment was laid-out in factorial randomized complete block designwith three replications. The treatments consisted of three sowing methods *viz.* broadcasting, ridge and furrow and raised bed and four INM practices*viz.* 50% RDF (recommended dose of fertilizer) + 50% FYM (farm yard manure), 50% RDF + 50% poultry manure, 50% RDF + 50% vermicompost and control. The fieldwas prepared according to local practices being followed by farmers for pearl millet production. The hybrid variety 'Kaveri Super Boss' was sownas pertreatments specification on August 8, 2013 with the help of hand operated kudal at spacing of 45 x 15 cm with seed rate @4 kg ha^{-1}in 4.5 x3 m^2 gross plot size under 8 years old guava based agri-horti system. The nutrient requirement, as per treatments, was supplied from urea, single super phosphate, murate of potash, FYM, poultry manure and vermicompost, respectively. All the nutrient sources were applied at time ofsowing. The crop was raised by following standard agronomic procedures and need based cultural operations were also adopted to keep the crop in vigorous condition. The crop was fully raised as rainfed crop. The 10 plants in each plot were randomly selected and tagged and were subsequently used for recording growth parameters (at 30, 60 DAS and at harvest) and yield attributes by adopting standard procedures. The crop from net plots after discarding border area plants was harvested and used for recording grain, straw and biological yield. The harvest index was calculated using following equation

$$Harvestindex = \frac{Economicyield\ (kgha^{-1})}{Biologicalyield\ (kgha^{-1})} X100 \quad (1)$$

To workout the economics of the treatments, the cost of inputs involved in raising crop and output price were used as per local market and accordingly cost of cultivation, gross returns, net returns and B:C ratio were calculated. The data recorded as part of study were analysed as per procedure described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth and yield: The growth and yield data are presented in table 1. It was evident fromthe results that the sowing methods and INM significantly (P=0.05) influenced all the growth parameters and yields. Among

Table 1. Sowing methods and INM affects growth (60 DAS) and yield of pearl millet under agri-horti-system in rainfed condition.

Treatments	Plant height (cm)	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	No. of green leaves plant^{-1}	No. of tillers plant^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Sowing methods									
Broadcasting	125.5	138.4	58.4	10.7	1.58	1102	3513	4615	23.9
Ridge and furrow	147.7	157.8	72.7	11.2	2.00	1412	3972	5384	26.2
Raised bed	144.7	153.6	66.9	10.9	1.92	1365	3917	5282	25.8
CD (P=0.05)	2.79	4.30	6.60	0.28	0.13	69	118	135	-
INM									
50% RDF+50% FYM	142.7	154.0	72.6	10.8	1.89	1260	3698	4958	25.4
50% RDF+50% poultry manure	151.9	162.0	79.7	11.4	2.22	1552	4360	5912	26.3
50% RD +50% vermicompost	148.3	156.9	75.7	11.3	2.15	1478	4139	5657	26.1
Control	144.0	126.9	35.8	10.2	1.08	883	2966	3849	22.9
CD (P=0.05)	3.23	4.97	7.63	0.33	0.14	80	136	156	-

Table 2. Interaction effects of sowing methods and INM on grain, stover and biological yield of pearl millet under agri-horti-system in rainfed condition.

Treatments	INM				
Sowing methods	**50% RDF+50% FYM**	**50% RDF+50% poultry manure**	**50% RDF+50% vermicompost**	**Control**	**Mean**
Grain yield (kg ha^{-1})					
Broadcasting	1009	1332	1248	820	1102
Ridge& furrow	1432	1691	1594	932	1412
Raised bed	1338	1633	1592	898	1365
Mean	1260	1552	1478	883	
CD (P=0.05)	139				
Stover yield (kg ha^{-1})					
Broadcasting	3312	4075	3700	2967	3513
Ridge& furrow	3931	4519	4423	3014	3972
Raised bed	3850	4488	4414	2917	3917
Mean	3698	4360	4179	2966	
CD (P=0.05)	236				
Biological yield(kg ha^{-1})					
Broadcasting	4321	5406	4948	3786	4615
Ridge &furrow	5364	6209	6017	3946	5384
Raised bed	5189	6121	6006	3814	5282
Mean	4958	5912	5657	3849	
CD (P=0.05)	270				

Table 3. Sowing methods and INM affects yield attributes of pearl millet under agri-horti-system in rainfed condition.

Treatments	Effective tillers hill^{-1}	Panicle length (cm)	Panicle girth (cm)	Grains panicle^{-1}	Grain weight panicle^{-1} (g)	Test weight (g)
Sowing methods						
Broadcasting	1.42	13.8	5.37	1340.8	12.3	7.46
Ridge and furrow	1.77	17.9	6.12	1508.3	13.9	9.23
Raised bed	1.64	17.2	5.84	1453.3	13.4	8.67
CD (P=0.05)	0.20	1.55	0.30	62.2	0.74	0.54
INM						
50% RDF+50% FYM	1.65	16.0	5.99	1427.8	12.8	8.87
50% RDF+50% poultry manure	2.00	18.8	6.19	1615.6	14.5	9.76
50% RDF+50% vermicompost	1.87	17.6	6.05	1543.3	13.4	9.42
Control	0.91	12.8	4.88	1016.7	7.1	5.76
CD (P=0.05)	0.23	1.79	0.35	71.8	0.86	0.86

Table 4. Sowing methods and INM affects economics of pearl millet under agri-horti-system in rainfed condition.

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Sowing methods				
Broadcasting	19802	51800	31997	1.68
Ridge and furrow	20772	57144	36371	1.79
Raised bed	21160	56352	35192	1.70
CD (P=0.05)	2573	1213	1267	0.05
INM				
50% RDF+50% FYM	21540	54445	32905	1.53
50% RDF+50% poultry manure	21588	59816	38227	1.77
50% RDF+50% vermicompost	24108	58437	34328	1.42
Control	15076	47697	32621	2.17
CD (P=0.05)	2228	1051	1189	0.06

sowing methods, ridge and furrow resulted higher growth parameters and yields consisting of grain, stover and biological yield followed by raised bed and broadcasting, respectively. Adoption ofridge and furrowsowing method increased 2 and 19.2% plant height, 2.7 and 19.4% fresh weight and 8.6 and 14.3% dry weight over raised bed and broadcasting, respectively. The no. of green leaves and tillers plant^{-1}across sowing methods ranges between 10.7-11.2 and 1.58-2, respectively. Concerning grain, stover and biological yield, ridge and furrow sowing method further adjudged better over rest of the sowing methods and recorded almost 28, 13 and 16% more grain, stover and biological yield, respectively than broadcasting. Our results are in agreement with the research findings of Kantwa *et al*. (2006) and Parihar *et al.* (2010).The har-

vest index varied between 23.9-26.2% across the sowing methods but higher harvest index (26.2%) was recorded with ridge and furrow method. Among INM practices, the application of 50% RDF + 50% poultry manure observed significantly higher growth and yield. Whereas, application of 50% RDF + 50% FYM observed lowest growth and yield among nutrient management practices but performed fairy better than control. Being superiorINM practice, 50% RDF + 50% poultry manure increased plant height (5%), fresh weight (27.6%) and dry weight (122.6%) over control. The maximum and minimum grain, stover and biological yields were recorded with 50% RDF + 50% poultry manure and control, respectively butamong INM practices, poultry based practice recorded significantly higher grain, stover and biological followed by 50% RDF + 50% vermicompost and 50% RDF + 50% FYM, respectively. Poultry based INM practice increased grain, stover and biological yield in the tune of 75, 46 and 53% over control, respectively. INMalso influenced harvest index, which ranges from 22.9-26.3% across the treatments. The highest harvest index (26.3%) was recorded with 50% RDF + 50% poultry manure followed by 50% RDF + 50% vermicompost but lowest harvest index (22.9%) was observed with control. It was also observed that the application of 50% RDF + 50% poultry manure recorded almost 15% increase in harvest index over control. These results closely corroborate with the research findings of Parihar *et al.* (2010) and Bana *et al.* (2016).Interaction effects of sowing methods and INM was found to be significant (P=0.05) for grain, stover and biological yield. The combination of ridge and furrow and 50% RDF + 50% poultry manure recorded highest grain (1691 kg ha^{-1}), stover (4519 kg ha^{-1}) and biological yield (6209 kg ha^{-1}) over rest of the combinations.

Yield attributes: The yield attributes *viz.* effective tillers $hill^{-1}$, panicle length (cm), and panicle girth, grains $panicle^{-1}$, grain weight $panicle^{-1}$(g) and test weight were recorded and presented in table 3. It was seen from the data that sowing methods and INM significantly(P=0.05) influenced yield attributes of pearl millet. Among the sowing methods, the highest [panicle length (17.9 cm), grains weight $panicle^{-1}$ (1508.3) and test weight (9.23 g)] and lowest [panicle length (13.8 cm), grains weight $panicle^{-1}$(1340.8) and test weight (7.46 g) yield attributes were observed with ridge and furrow and broadcasting, respectively. However, raised bed observed yield attributes [panicle length (17.2 cm), grains weight $panicle^{-1}$(1453.3) and test weight (8.67 g)] at par with ridge and furrow but significantly higher than broadcasting. Ridge and furrow method not only increased grains $panicle^{-1}$ (12.5%), grain weight $panicle^{-1}$ (13%) and test weight (23.7%) over broadcasting but also significantly increased effective tillers $hill^{-1}$, panicle length, and panicle girth in the tune of 24.6, 29.7 and 14%, respectively. The superiority of ridge and furrow sowing method might be due to proper drainage of excess rainfall water and better moisture conservation (Kantwa *et al*., 2006: Parihar *et al.,* 2010).With respect to INM practices, the highest yield attributes were recorded with 50% RDF + 50% poultry manure (NPK-1.3, 0.4 and 0.7%, respectively) followed by50% RDF + 50% vermicompost, 50% RDF + 50% FYM and control, respectively. It was observed from the results that maximum increase in yield attributes over control was recorded with 50% RDF + 50% poultry manure followed by 50% RDF + 50% vermicompost and 50% RD + 50% FYM, respectively. Furthermore, poultry based INM recorded significantly (P=0.05) higher yield attributes than 50% RDF + 50% FYM but at par with 50% RDF + 50% vermicompost. Application of organic materials recorded better results over control might be due to balanced supply of major and micro nutrients and increase in water holding capacity of soil. Almost similar research findings have also been reported by Parihar *et al.* (2010) and Bana *et al.* (2016).

Economics: The economics data *viz.* cost of cultivation, gross and net returns and B: C ratio are presented in table 4. Sowing methods and INM significantly (P=0.05) influenced pearl millet economics. The highest and lowest gross and net returns and B:C ratio among the sowing methods, were recorded withridge and furrow and broadcasting, respectively.Ridge and furrow sowing method recorded significantly higher gross (10.3%) and net returns (13.6%) and B: C ratio (6.5%) over broadcasting but performed at par with raised bed. Similar research findings were also reported by Kantwa *et al*. (2006) and Parihar et al (2010).With respect to INM, the highest gross returns, net returns and B:C ratio was recorded with 50% RDF + 50% poultry manure followed by 50% RDF + 50% vermicompost, 50% RD + 50% FYM and control, respectively. The results also indicated that theapplication of 50% RDF + 50% poultry manure performed significantly better than 50% RDF + 50% FYM and control but at par with 50% RDF + 50% vermicompost with respect to gross, net returns and B:C ratio. Our results corroborate the research findings of Bana et al (2016).

Conclusion

It is concluded that ridge and furrow sowing method and 50% RDF + 50% poultry manure INM practice were the best for enhancing growth viz. plant height (147.7 and 151.9 cm), dry weight (72.7 and 79.7 g), yield attributes viz. panicle length (17.9 and 18.8 cm) and test weight (9.23 and 9.76 g), yield grain (1412 and1552 kg ha^{-1}) and biological yield (5384 and 5912 kg ha^{-1}) and economics in terms of net returns (Rs. 36371 and 38227 ha^{-1}) and B:C ratio (1.79 and 1.77) of

pearl millet grown as intercrop under guava based agri-horti system in rainfed conditions of Vindhyan region of Uttar Pradesh.

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